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Testing of the Mishimoto Top-Mount Intercooler – Part 1

Test Vehicle
2004 Subaru WRX with JDM 2.0L STI engine swap

Modifications
Downpipe, 3" exhaust, air intake, boost pressure at 20–22 psi

Objective
Improve intercooler efficiency. Must be direct fit for all 2002-2007 WRX and STI models.

Testing Conditions
Ambient temperature 61˚F, atmospheric pressure 29.33 in Hg, humidity 13%.

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Apparatus

Dynojet 424X dynamometer with Linx. For temperature and pressure monitoring Mishimoto chose the PLX sensor modules driven by the Kiwi WiFi plus iMFD. This is a wireless system from the sensor modules to an iPad or laptop computer. The software used was the Palmer Performance Scan XL pro, which has full data logging capabilities.

Figure 1: PLX sensor modules were used to monitor engine pyrometers.

Intercooler Design Concepts

The design of the Mishimoto intercooler is quite unique, so we wanted to include some background on the design concepts. First, CAD models of all the different WRX intercoolers were made and these models were used to study fitment and flow. Using CFD software, it was found that the Y-pipe connection did not allow air to flow as well when compared to typical

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intercoolers that were tested previously. Incoming air must make a 180-degree turn inside the upper end tank before it can travel through the core. This sharp turn in an open space does not result in optimal flow. To improve flow Mishimoto decided to make the bends and curves in the boost pipe rather than in the intercooler itself. Adding these bends is not ideal, but the S-shape allows for better airflow through the intercooler and it distributes the air more evenly than does the stock Y-pipe and upper intercooler tank design.

Figure 2: CAD rendering of the intercooler before first prototype

The second design concern was placement of the S-pipe over the turbo and downpipe area; this was addressed in two ways. First, a special high-temperature silicone (a very good isolator) was used. This material can withstand temperatures of up to 500˚F. Next, the temperature was measured in and around the S-pipe under different conditions. A thermocouple was placed outside and under the silicone boost pipe during the dyno runs to determine the external temperature of the boost pipe. Those temperatures on the dyno were around 140°F –190°F. Testing of the same area during normal street driving revealed temperatures of 120°F –160°F on the road and a maximum of 260°F in stop/idle conditions. When the outside of the silicone boost pipe was in an idle environment, the internal temperatures of the pipe were about 100°F lower than the external temperatures at stop/idle. Final testing revealed that the internal temperatures inside the boost tube (which can reach 300˚F) were actually higher than the external temperatures of the boost tube. Since Mishimoto's S-pipe can withstand temperatures up to 500°F, there is no worry of the pipe ever failing; Mishimoto guarantees it.

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Experiment

Stock STI and aftermarket intercoolers are popular upgrades for WRX owners who want more power from their engines. We chose to test the Mishimoto intercooler against the stock STI and another aftermarket intercooler instead of the less efficient stock WRX intercooler. These test comparisons are a better representation of the needs of the WRX community. (Please note: Owners with stock WRX intercoolers can expect better results than shown below, because the stock STI intercooler outperforms the stock WRX intercooler in every category).

When the test vehicle was warmed up, we made five runs or more until we had three consistent dyno plots. Three-minute breaks between runs allowed the vehicle to cool down. No additional tuning or any other changes were performed other than simply swapping the intercoolers. Temperature and pressure data were taken from the turbo outlet as well as the intercooler outlet. All temperature and pressure data shown below were averaged from three consistent runs, as were the dyno plots.

Results

Colder air is denser than hot air and will therefore allow a larger combustion while also reducing the chances of engine knock. As the post-intercooler temperatures become colder, a tuner is able to load a more aggressive timing map into the vehicle's ECU, which will directly result in more power. An intercooler's primary function is to reduce the outlet temperature significantly and with the best possible efficiency. This requires a large amount of heat transfer with the least possible pressure drop. By utilizing a larger core, optimizing the intercooler's fins, and improving on the airflow distribution, Mishimoto achieved this goal.

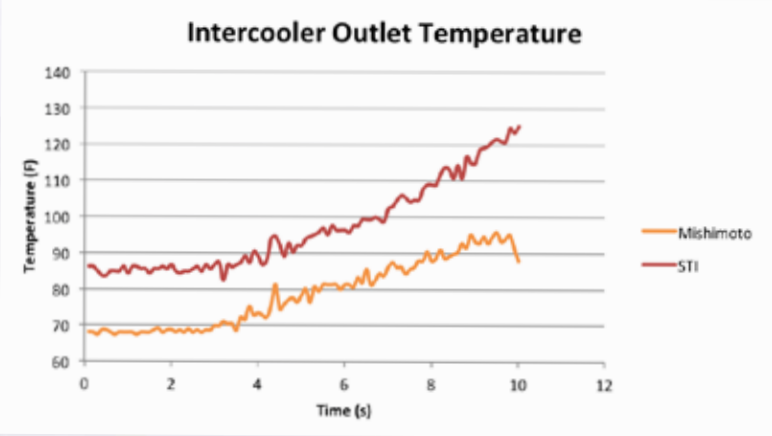

Figure 3: The Mishimoto intercooler outlet temperature shows an average decrease of 15˚F and a maximum of 30˚F.

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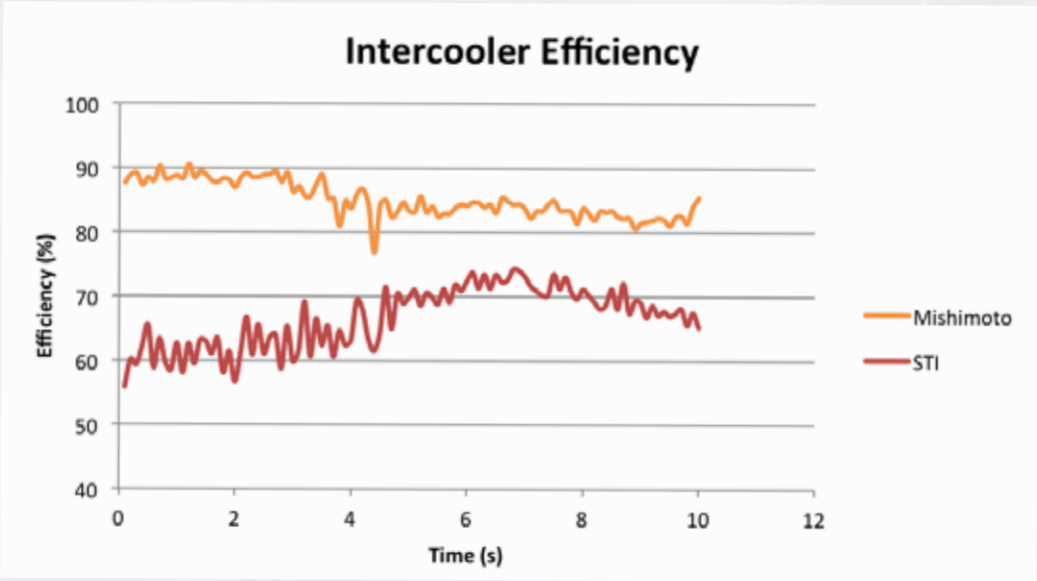

Figure 4: The Mishimoto intercooler shows an average efficiency of about 85% compared to the STI efficiency of approximately 70%.

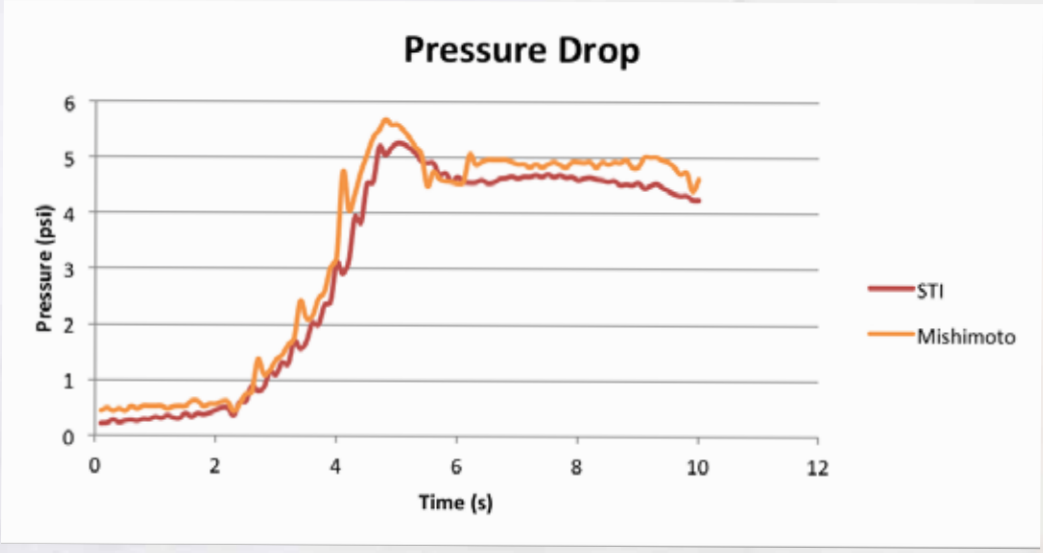

Figure 5: Mishimoto intercooler shows little increase in pressure drop compared to the STI.

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Figure 6: Mishimoto intercooler shows gains of up to 14 hp in the 5500+ rpm range.

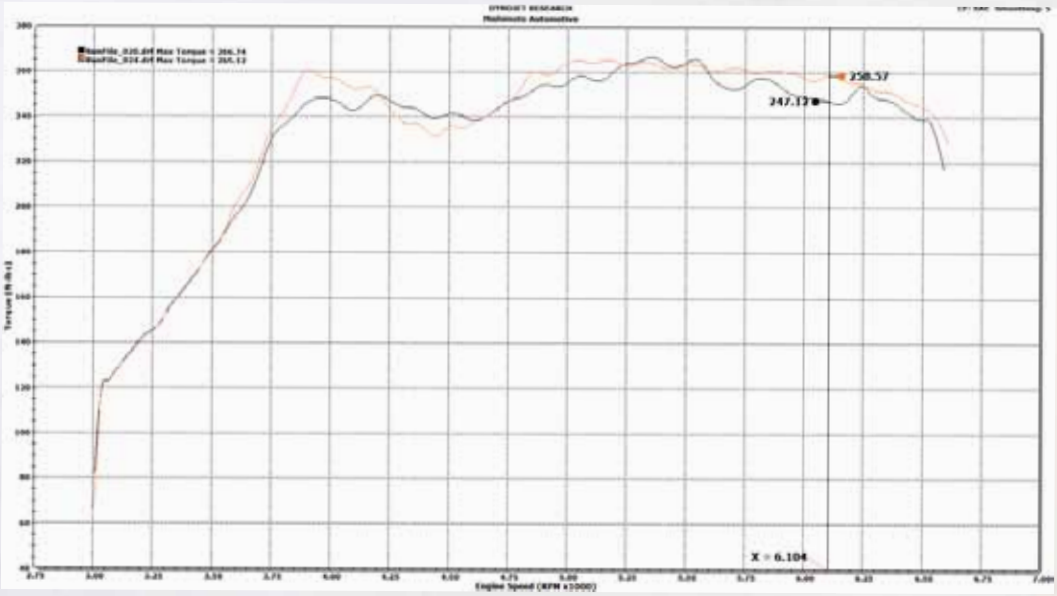

Figure 7: Mishimoto shows significant torque gains of up to 11 ft-lb in the 5500+ rpm range.

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Testing of the Mishimoto Top-Mount Intercooler – Part 2

Test Vehicle
2003 Subaru WRX

Modifications
18G turbocharger, aftermarket intercooler, aftermarket injectors, downpipe, 3" exhaust, air intake, boost pressure at 15–16 psi

Experiment
This test vehicle was used to find out how the intercoolers would perform with a large, high-flow turbocharger. It was important to verify that the new S-shaped intercooler hose was not restrictive and would work well in a high-flow environment. For the comparison we used an aftermarket intercooler (not Mishimoto) that is well known and respected. We could not obtain temperature and pressure data because the owner did not permit us to modify the vehicle's aftermarket intercooler.

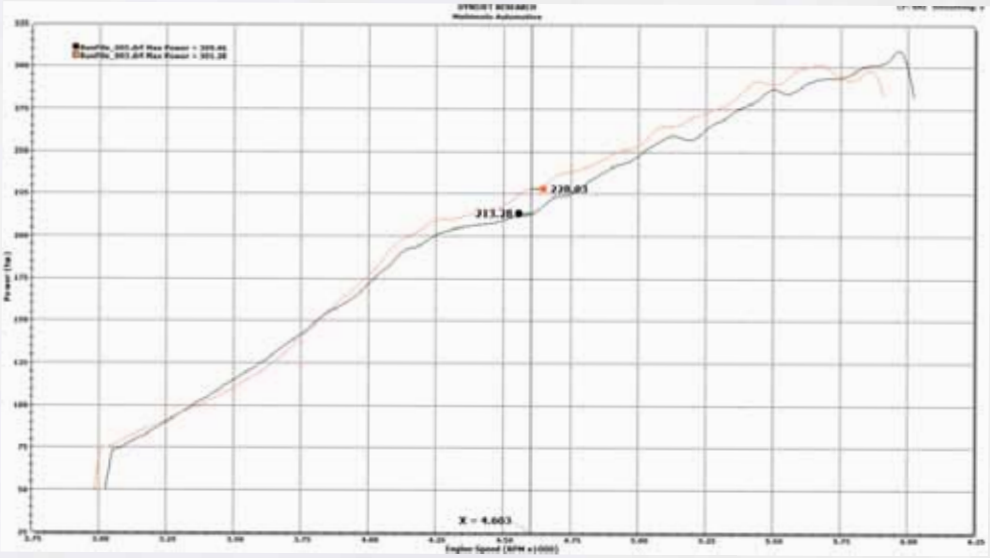

Figure 8: Mishimoto intercooler shows improved power across the entire power band, with a maximum gain of 15 hp.

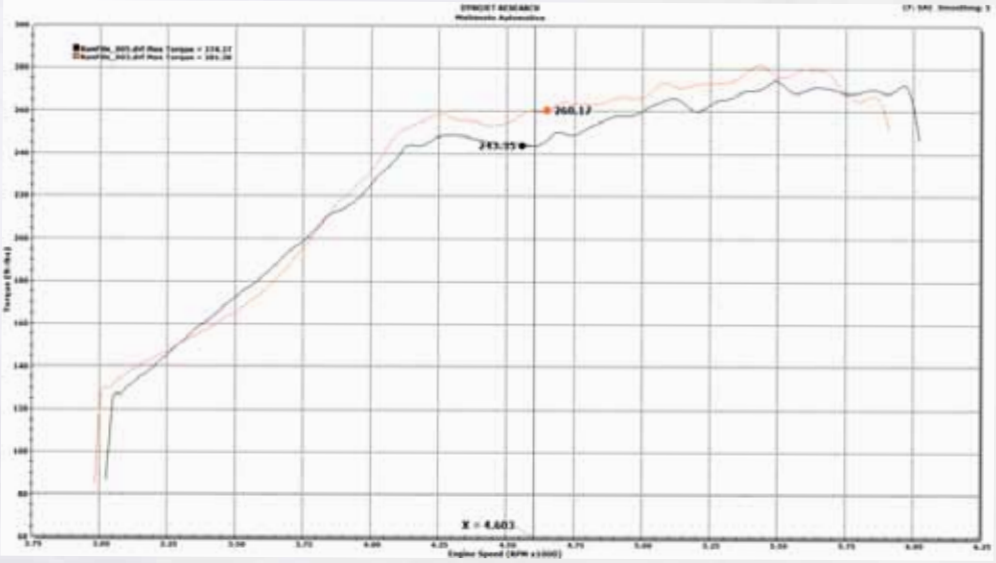

Figure 9: Mishimoto intercooler shows torque gains across the entire power band, with a maximum gain of 17 ft-lb

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Summary

The Mishimoto intercooler demonstrated improved horsepower and torque, equal pressure loss, and lower air intake temperature over the stock STI intercooler. Both test comparisons confirm that the side-entry design works well, allowing for a more even distribution of incoming air from the turbocharger, without increased pressure loss.

Another benefit that should not be overlooked is the simplified installation process. All Subaru owners know that reinstalling the stock Y-pipe to the turbo connection can be frustrating. Mishimoto's side-entry design, however, allows you to connect your boost pipe to the turbo before installing and bolting down the intercooler. What's more, Mishimoto's unit can be installed in just a few minutes!

All engineers agree that the time spent on this research and development was well worth it. The engineering involved in this project allows Mishimoto to produce an intercooler that performs better, installs easier, and comes in at a great price.

Kevin McCardle, Product Engineer, Mishimoto Automotive